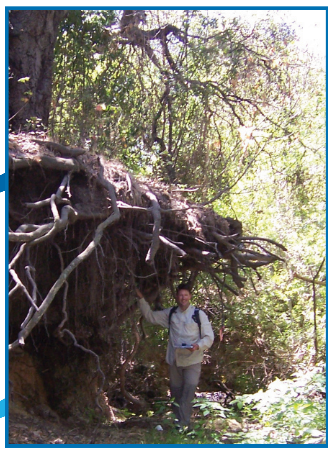
The Unified Stream Assessment: Potential Uses for Stormwater Programs

San Francisco Bay Area Examples



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Foreward

This document is intended to provide guidance to municipal stormwater programs and other interested agencies on the potential uses of the Unified Stream Assessment (USA) based on recent experience in the San Francisco Bay Area. The USA is a rapid assessment tool developed by the Center for Watershed Protection (CWP) to collect data on instream and riparian habitat conditions, and identify possible influencing factors and opportunities for improvement. We take this opportunity to thank the CWP for their efforts in developing and testing this protocol, and for making it available to the public. The examples used herein to demonstrate potential uses of the USA were made possible by funding from the following municipal stormwater mangagement programs: the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), and the Alameda County Clean Water Program (ACCWP).

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Introduction

Urban creeks are influenced by a multitude of factors that affect the quantity and quality of available water and instream and riparian habitat. In order to meet the requirements in National Pollutant Discharge Elimination System (NPDES) permits issued under the Federal Clean Water Act, stormwater programs are faced with the extremely challenging task of assessing and identifying whether stormwater discharges are causing or contributing to water quality problems, and implementing best management practices (BMPs) to reduce these impacts to the maximum extent practicable. Different protocols may assist in achieving these objectives efficiently and effectively including the Unified Stream Assessment (USA).

The USA has been extensively field-tested by the Center for Watershed Protection (CWP) (2005) and used to evaluate creek and riparian conditions in multiple San Francisco Bay Area watersheds, including Calabazas, Saratoga, and Matadero Creeks in Santa Clara County, Martin Canyon and Ward Creeks in Alameda County, and 13 watersheds in San Mateo County. Additionally, it has been implemented by cities, counties, and states across the nation (including Durham County, North Carolina (Hoyt and Kitchell 2007), Clark County, Washington (Clark County NPDES Clean Water Program 2005), State of Maryland (Department of Natural Resources 2005), State of Virginia (U.S. Army Corps of Engineers, Norfolk District, Virginia Department of Environmental Quality 2007), and Westchester County, New York (Westchester County Department of Planning 2007).

In future years, Phase I municipal stormwater programs in the San Francisco Bay Area (Bay Area) will likely be required to conduct stream surveys using the USA or an equivalent method. Data generated through USA surveys can address multiple stormwater monitoring-related objectives. Stormwater programs that need to further develop their monitoring programs may conduct USA surveys to establish baseline data, identify the types and locations of potential impacts to water quality, identify potential Beneficial Uses to protect and threats to such Uses, and identify or refine monitoring objectives, parameters and sampling locations. Programs may also use USA survey data to better understand stream conditions and threats to water quality upstream and downstream of existing monitoring sites, thereby assisting in the interpretation of existing monitoring data, and the identification of appropriate stormwater BMPs and potential restoration activities. The purpose of this document is to provide guidance to municipal stormwater programs and other interested agencies on the potential uses of the USA based on recent experience in the Bay Area.

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The Unified Stream Assessment (USA) Protocol

The USA protocol[1] initally published by the CWP in 2004, and is designed to rapidly and systematically assess instream and riparian corridor conditions, and identify restoration and rehabilitation opportunities for urban creeks. This method is a composite of previously published stream assessment protocols, including the Stream Corridor Assessment Survey (Yetman 2001), the Rapid Bioassessment Protocol (Barbour et al., 1999), the Outfall Reconnaissance Inventory (Brown and Araco 2004), the Rapid Channel Assessment (Booth 1994), and the Stream Keepers Field Guide (Murdoch and Cheo 1999).

The USA protocol assesses overall creek reach conditions and specific point impacts within each reach. To assess conditions within a creek reach, a continuous upstream walk is conducted, during which information is collected about stream corridor conditions, such as average bank stability, instream and riparian habitat, and floodplain connectivity. Parameters are scored on a continuous scale and summarized as a weighted average to reflect overall instream condition, overall buffer and floodplain condition, and overall reach condition.

In addition to assessing reach-wide conditions, notable impacts occurring within each reach are recorded on separate forms[2] . Eight categories of impacts are included in the USA (see sidebar): 1) severe stream erosion, 2) impacted stream buffers, 3) utilities, 4) trash and debris, 5) stream crossings, 6) channel modifications, 7) stormwater outfalls, and 8) a catch-all category for miscellaneous features. To assess sites with potential recreational uses, a ninth assessment form was developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP). Additionally, SCVURPPP created streamlined versions of several impact forms to accommodate projects that do not require as much detailed data. These versions are designed to provide an inventory of features that may have minor impacts on the creek resources, but are not deemed to require immediate attention. The original impact assessment forms are still used to document features that appear to have considerable impact on creek resources.

USA Impact Assessments

1. Stream erosion
2. Stream buffers
3. Utilities
4. Trash and debris
5. Stream crossings
6. Channel modifications
7. Stormwater outfalls
8. Miscellaneous features
9. Recreation sites

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[1] The USA method is just one component of the CWP's integrated framework for urban watershed restoration. The CWP framework includes a series of eleven manuals that focus on techniques to identify and address conditions in urban watersheds in a format that can easily be accessed by watershed groups, municipal staff, environmental consultants, and other users. The USA assessment is described in manual 10.

[2] To facilitate data collection in the field and data recording afterwards in the office, SCVURPPP has designed a simplified impact inventory form (Appendix A) that is used to record impacts that are not considered to relatively minor and do not need to be documented at the level of detail required by the full impact assessment form. The USA impact assessment forms, however, are still used when observed impacts required additional space to fully document them.

Prior to field data collection, several key tasks must be completed by the agency conducting the assessment. One such task is the compilation of existing information that may be used to characterize the study area and classify stream reaches. Streams are classified to identify reaches that have relatively uniform hydrological and geomorphological characteristics so that scores for instream and riparian condition are representative of each reach. Table 1 describes criteria that are typically used to classify stream reaches. Reaches that are identified using mapped data are commonly refined during field observations of channel conditions.

A second critical task is to conduct field reconnaissance to identify potential creek-access points and barriers to accessing upstream locations. For example, long culverts under roadways or dense thickets of poison oak can inhibit access to upstream reaches. Additionally, restricted access to private property may also prohibit field crews from assessing particular reaches, unless permission is granted by property owners[3].

Although the USA is a relatively rapid and inexpensive assessment tool, several factors influence the scope and budget for a USA survey, including the number of stream miles to cover, the density of impacts in the stream corridor, and the level of detail associated with data collection. Depending on the terrain and the number of impacts, a two-person field crew may cover between ½ - 2 miles/day. Equipment needs are nominal and include a GPS unit, a hip chain (used to measure stream lengths for impacts and for stream location when satellite coverage is poor), a digital camera, hip and/or chest waders, and street maps (orthophotos may be helpful in the field depending on their spatial resolution and the density of tree canopy, but are not necessary).

Table 1. Criteria used to classify USA stream reaches in San Mateo County watersheds.

Criteria	Stream Characteristics
Channel planform	Increase in channel sinuosity typically results in higher flood plain connectivity; and often correlates with greater riparian setbacks.
Channel gradient	Steepening of channel slopes typically results in increases in substrate size and flow velocities.
Channel modification	Reaches with continuously hardened channels or culverts result in highly altered stream and riparian habitats.
Grade control structure	Construction of road/train crossings and dams/diversions can result in changes to channel bed elevations.
Tributary confluence	Changes in flow volume can result in changes in channel width and flow velocities.
Land use type	Changes from urbanized to non-urbanized land uses typically exert fewer and/or different types of impacts to stream and riparian resources..

[3] Prior to beginning fieldwork, municipal stormwater programs in the San Francisco Bay Area typically send letters to creekside property owners requesting access to the creek on their property.

Potential Uses and Implementation Strategies

The USA protocol can be used to address multiple objectives for creek monitoring and assessment programs. In the Bay area, it has been used successfully to: 1) guide the design of monitoring programs; 2) assist in the interpretation of existing physical, chemical, and biological monitoring data; and, 3) to identify potential water quality impacts and BMPs to address such impacts. Each of these potential uses of the USA is discussed in further detail in the following sections. Additionally, case studies are summarized to provide examples of how the USA has been applied in the Bay area.

Guiding the Development of Monitoring Programs

Data generated through USA surveys may be used to guide the development of water quality monitoring programs by:

- Establishing baseline data in creeks/streams;
- Identifying the type and location of potential impacts to water quality;
- Identifying potential Beneficial Uses and associated threats to such Uses; and,
- Identifying monitoring objectives, parameters and sampling locations.

Establishing Baseline Data

In creeks that have limited or no existing environmental data, initial monitoring objectives may include the characterization of baseline water body conditions. The USA's reach-level assessment can provide a qualitative baseline condition across an urban gradient for instream habitat and riparian and floodplain conditions, as well as for other features such as stream dimensions, stream flow, dominant substrate size, water clarity, presence/absence of aquatic animals and plants, and predominant channel dynamics (e.g., downcutting, widening). These data can also be used to identify potential mechanisms that may impact stream ecosystem functions (e.g., floodplain connectivity) and channel processes (e.g., bank erosion) (see Case Study #1). Such baseline data may be supplemented subsequently with more detailed, quantitative measurements. For example, channel dimensions (e.g., bankfull width and depths) can be measured to determine the location and extent of flood prone areas within each reach;, and the size of bedded substrates may be measured using established protocols to better understand sediment dynamics.

Identifying Potential Water Quality Impacts

Assessments of impacts from erosion, channel modification, stream crossings, outfalls, utilities, trash and encroachment of riparian buffers can be used to evaluate the extent (Figures 1a-c) and magnitude (Table 2) of potential water quality impacts associated with urbanization. Illicit discharges from outfalls and litter accumulation areas are two examples of impacts that are commonly reported to public works departments for follow-up.

Case Study #1

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) used the USA to characterize baseline conditions in thirteen urban watersheds (78 reaches within 34 miles of creeks) in San Mateo County during the fall seasons of 2006 (SMCWPPP 2007) and 2007 (SMCWPPP, in preparation). The USA results from Cordilleras Creek (Figures 1a-c) indicated a pattern typically observed in San Mateo watersheds, i.e., a decrease in instream habitat quality and riparian condition as elevation decreases and urbanization increases (i.e., moving East towards the San Francisco Bay). The presence of deeply incised channels with limited flood-prone areas and setback distances, and heavily modified banks with predominately non-native riparian vegetation negatively influenced reach scores, as shown for Reach 3 (Figures 1a-c).

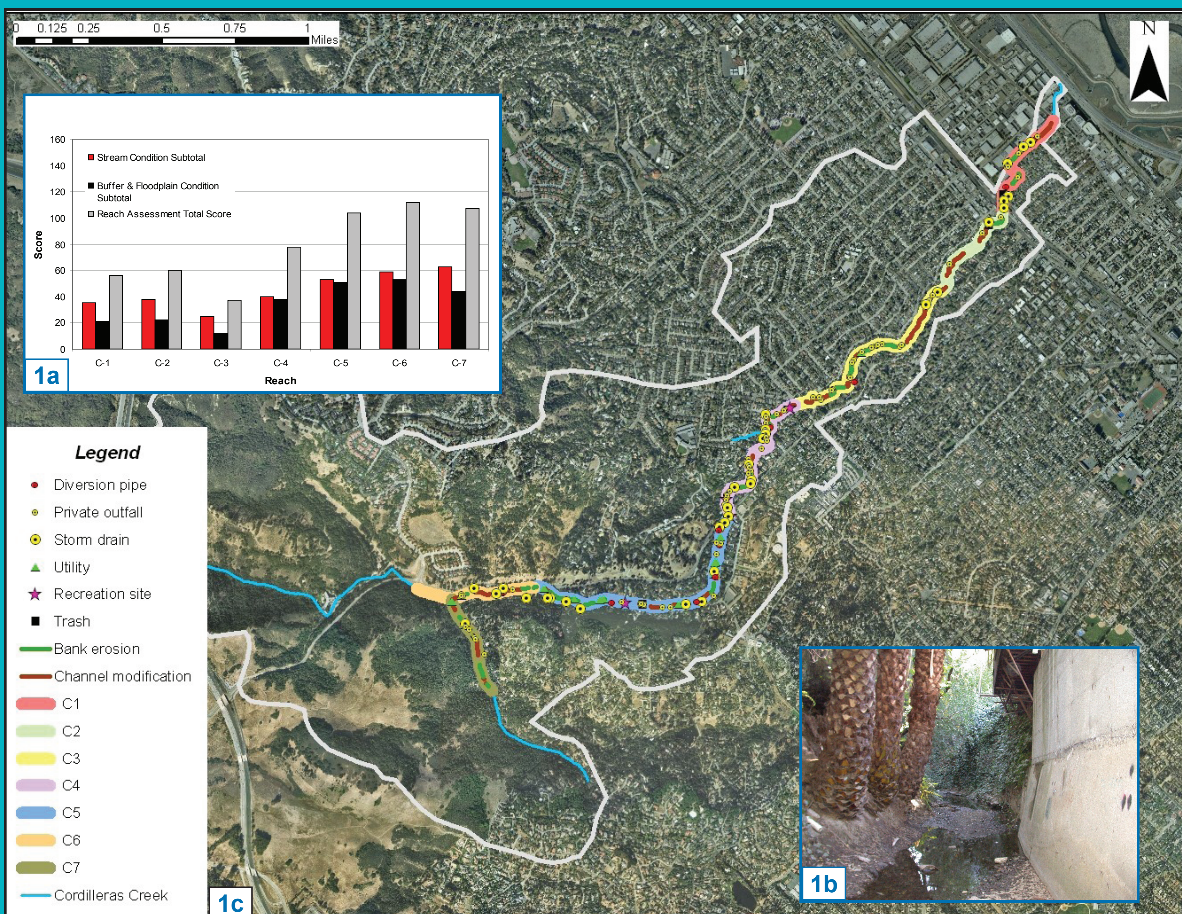

Figure 1. Cordilleras Creek, San Mateo County: a) USA Reach assessment scores; b) Example of an incised channel impacted by armoring and non-native streambank vegetation; and, c) Type and location of impacts documented during the USA survey.

The type and/or amount of data collected for each of these impacts can be modified depending upon a program's monitoring objectives. For example, detailed measurements of bank erosion or channel modification impact sites may not be needed if monitoring objectives do not include stream restoration. On the other hand, detailed measurements may be desired when a monitoring objective is to identify and map invasive plant species in the riparian corridor. When impacts are detected, additional monitoring can be designed to further evaluate the magnitude of such impacts or to measure biological responses. For example, when excessive erosion is observed in a stream reach, water quality and bioassessments may be conducted up- and down-stream of the erosion sites to better understand and quantify potential impacts.

Table 2. Impact assessment summary for the Cordilleras Creek watershed.

	Creek Reach ID						
	C1	C2	C3	C4	C5	C6	C7
Length of Reach (ft)	1,940	1,675	4,045	2,935	5,315	1,800	1,815
Channel Modification							
Length of Channel Mod (ft)	900	955	2,505	1,390	1,050	1,225	743
Percent of Reach Modified	46	57	62	47	20	68	41
Erosion							
Total Length Eroded (ft)	415	175	1,180	455	2,126	130	355
Percent Eroded	21	10	29	16	40	7	50
Outfalls							
Total Number of Outfalls	13	6	20	32	29	11	8
Diversion pipe	2	0	0	2	5	1	1
Private outfall	7	3	18	21	13	6	6
Storm drain	4	3	2	9	11	4	1
Number Creek Crossings	2	3	1	2	4	10	0
Number of Recreation Sites	-	-	-	2	2	-	-
Number of Trash Sites	2	1	-	-	1	-	-
Total Number of Utilities	-	-	1	1	9	3	3

Identifying Potential Beneficial Uses and Evaluating Use Support

Data collected with the USA protocol can be used to help agencies identify the location and type of some Beneficial Uses and evaluate Beneficial Use support. One way to identify the extent of support for aquatic life uses (e.g., fish and invertebrates) is to utilize the information about the presence and absence of fish species recorded on the Reach Assessment Form (see Case Study #2). Stream flow regime (i.e., intermittent, perennial) recorded during USA surveys, particularly when documented during the late summer season, can also provide valuable information to evaluate the degree to which such habitats can support both fish and benthic macroinvertebrate communities. Additionally, recreational uses may be identified by documenting evidence of water contact recreation sites during USA surveys. Stream locations with evidence of potential recreational uses may be given higher priority for future monitoring efforts to determine if Water Quality Objectives for bacterial indicators are being achieved(see Case Study #2).

Case Study #2

USA surveys conducted by the San Mateo Countywide Clean Water Program (SMCWPPP) were used to map the distribution of native fish communities in thirteen urban watersheds in San Mateo County (Figure 2) (SMCWPPP 2007; SMCWPPP in preparation). In addition to recording the presence or absence of fish species, potential impediments to fish passage at stream crossings were documented and used to help evaluate the degree to which fish can access different parts of the creek system. Potential recreation sites were also documented during these USA surveys (Figure 2) based on evidence of recreational use, such as the presence of rope swings over pools.

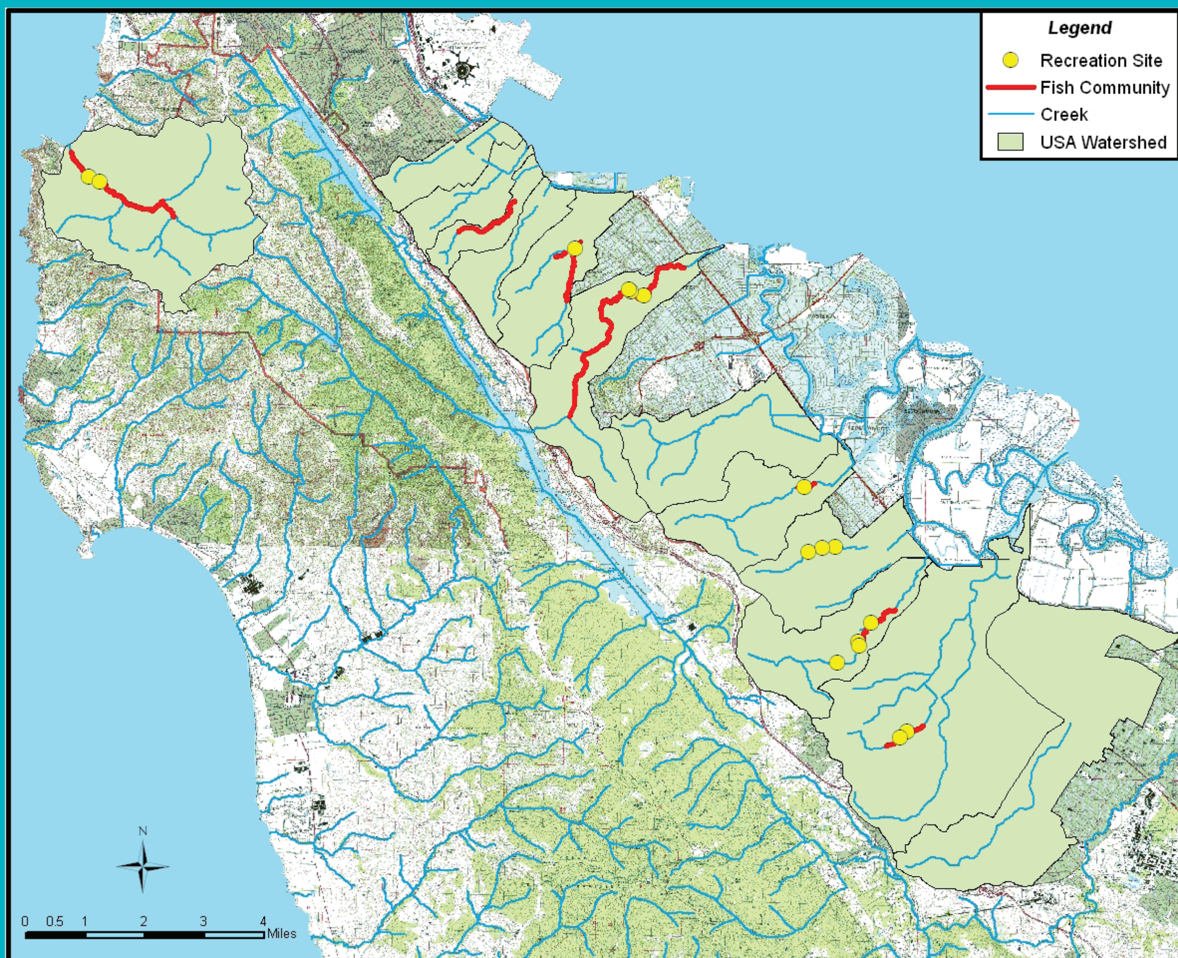

Figure 2. Presence of recreational sites and fish communities identified during USA surveys conducted in 13 San Mateo County watersheds.

Developing Monitoring Plans

Data collected during a USA survey can also be used to develop objectives and inform sampling designs for future monitoring activities in a creek. Instream habitat and riparian buffer conditions, evidence of existing aquatic life and/or recreational uses, and other impacts associated with urbanization are all important factors when developing a monitoring program (see Case Study #3).

Case Study #3

In spring 2006, the Alameda Countywide Clean Water Progam (ACCWP) conducted a USA survey along approximately 2.0 miles of Martin Canyon creek, a tributary to Alameda Creek in the City of Dublin, California (Figure 3). Analysis of the USA data and other existing data (see below) resulted in the recommendation of two primary monitoring objectives (ACCWP 2006).

Figure 3. ACCWP staff conducting a USA survey in Martin Canyon Creek.

Recommended Monitoring Objectives:

1. Evaluate the condition of Aquatic Life Uses in the watershed using biological indicators (i.e., benthic macroinvertebrate and fish community) and physical habitat assessments (including assessment of stream flow in late summer);
2. Identify potential impacts to Aquatic Life Uses by conducting continuous monitoring of water temperature and collecting grab samples of suspended sediment.

Results:

- The uppermost reach (4) exhibited the highest scores for instream habitat and riparian buffer condition, and the fewest impacts from urbanization. Therefore, Reach 4 appeared to have the greatest potential to support aquatic life uses;
- Extensive channel hardening and urban encroachment in reaches 1 and 3 provided limited potential capacity to support Aquatic Life Uses and instream habitat and riparian buffer ecosystem functions.
- Assessment scores in Reach 2 were low due to the presence of highly eroded banks and channel incision; however, restoration potential was high due to the presence of a wide potential riparian buffer on the left bank (i.e., adjacent land uses were in public ownership, as a City Park and a public school).
- Turbidity and deposition of fine sediment were observed throughout the study area. Although channel incision and bank erosion were documented in urban areas of Reach 2, substantial sediment supply appeared to be delivered from the non-urbanized upper watershed;
- Potential for public access to Martin Canyon was high, primarily in Reaches 2 and 4; however, potential for water contact Recreational Use was low due to low flow conditions and lack of deep-water habitat.

Interpretation of Existing Monitoring Data

In situations where monitoring data are available at a limited number of sites within a given creek, interpretation of these data may be associated with a high degree of uncertainty. Information generated from a USA survey can be used to help interpret such data and/or to refine future monitoring activities as follows:

- Extrapolate the existing site level data to larger areas of a creek that exhibit similar hydrologic and geomorphic characteristics, and/or refine sampling design;
- Improve understanding of stream conditions and threats to water quality upstream of existing monitoring sites;
- Identify potential threats to water quality at sites that lack existing information to evaluate impacts; and
- Habitat assessment data can assist in the interpretation of patterns observed in existing biological data.

The following paragraphs further discuss these uses of the USA and provide Bay Area stormwater programs examples.

Extrapolating Existing Data and/or Refining Sampling Design

As previously discussed, creek reaches are classified prior to implementing a USA survey based on the presence of similar hydrologic, geomorphic and adjacent land use characteristics. This process results in the delineation of reaches that have relatively uniform in-stream and riparian habitat conditions. Therefore, after conducting a USA survey, it may be possible to extrapolate, with greater certainty, existing site-specific monitoring data within part or all of a reach. It may also become apparent that existing monitoring sites, particularly if positioned within the same reach, provide redundant information, indicating a need to reconsider the locations of sampling sites. Conversely, impact assessment data may identify potential threats to water quality or habitat conditions within a reach, indicating a need to increase the number of sampling sites to evaluate such potential impacts. Clearly both of these scenarios greatly influence the cost:benefit ratio of long-term monitoring efforts.

Interpreting Data in a Watershed Context

Existing monitoring data for a given site may convey conflicting signals, particularly when knowledge of potential upstream impacts that may influence site conditions is limited. For example, benthic macroinvertebrate (BMI) data may indicate poor biological integrity at a sampling site, despite the presence of good quality physical habitat. In such a case, the BMI community may be affected by upstream impacts (e.g., outfall-discharges that contain chemical pollutants), as opposed to habitat at the site. Such upstream impacts would not necessarily be known following a BMI sampling event at the site. The continuous nature of the USA survey, however, can enhance understanding of stream conditions and potential impacts throughout a watershed.

Identifying Data Gaps

The USA reach and impact assessment data can also be used to identify sites where additional monitoring may be desired to address existing data gaps. For example, additional monitoring may be warranted at sites impacted by trash to evaluate possible sources and pathways entering creeks. Similarly, additional monitoring may be needed downstream of an outfall that exhibits poor water quality. In other cases, the USA may identify a natural resource, such as a native fish community, that needs protection. Additional future monitoring may be desired to evaluate the condition of the fishery and its population trends.

Interpreting Biological Response Data

Due to the spatial continuity inherent in USA survey data, they can be used to supplement existing monitoring data and help evaluate potential relationships between physical habitat condition and biological response indicators. A study recently conducted in Saratoga Creek by the SCVURPPP provides a good example of how USA information can help interpret biological data (see Case Study #4).

Case Study #4

In October, 2005, the SCVURPPP conducted a USA survey along approximately 6.75 miles of Saratoga Creek, in Santa Clara County, CA (SCVURPPP 2008) (Figure 4a). USA reach scores were plotted against BMI metric scores collected previously (SCVURPPP 2004, 2005) from seven sites within the USA survey area (Figure 4b) to compare trends between biological and physical indicators. The USA and BMI scores generally indicated a similar spatial trend, increasing in value with distance upstream towards the watershed's less-urbanized headwaters. However, USA reach scores in the vicinity of BMI site S-4, particularly those in Reach 6, deviated noticeably from this trend (Figure 4b). Compared to neighboring reaches, instream and riparian habitat in Reach 6 were greatly impacted by the lower proportion of streambank vegetation and floodplain connectivity coupled with increased streambank erosion (32% of reach) and channel modifications (28% of reach) (SCVURPPP 2008). Fish habitat survey data (SCVURPPP 2008) also indicated a marked decrease in quality (e.g., less boulder/cobble and bubble habitat, and greater embeddedness and percent sand in substrate) starting in USA reach 6 and extending downstream. Such comparisons prompted SCVURPPP staff to consider several hypotheses to explain why BMI scores did not reflect a decrease in this segment of the stream similar to that indicated by USA reach scores. One hypothesis was that the BMI sampling site was not representative of the entire reach (BMI sampling was conducted in targeted riffles, which may constitute the highest quality habitat available in the reach). Possibly, subsequent BMI sampling should be conducted using a multi-habitat protocol, and/or BMI should be sampled at another site between S-3 and S-4. A second hypothesis was that instream habitat was not as greatly influenced by the destabilized and/or modified streambanks and encroached riparian corridor as staff concluded from the USA survey data. Further geomorphic assessment could enhance understanding of channel dynamics in this reach. Both hypotheses indicated the need to consider conducting additional future sampling in Reach 6.

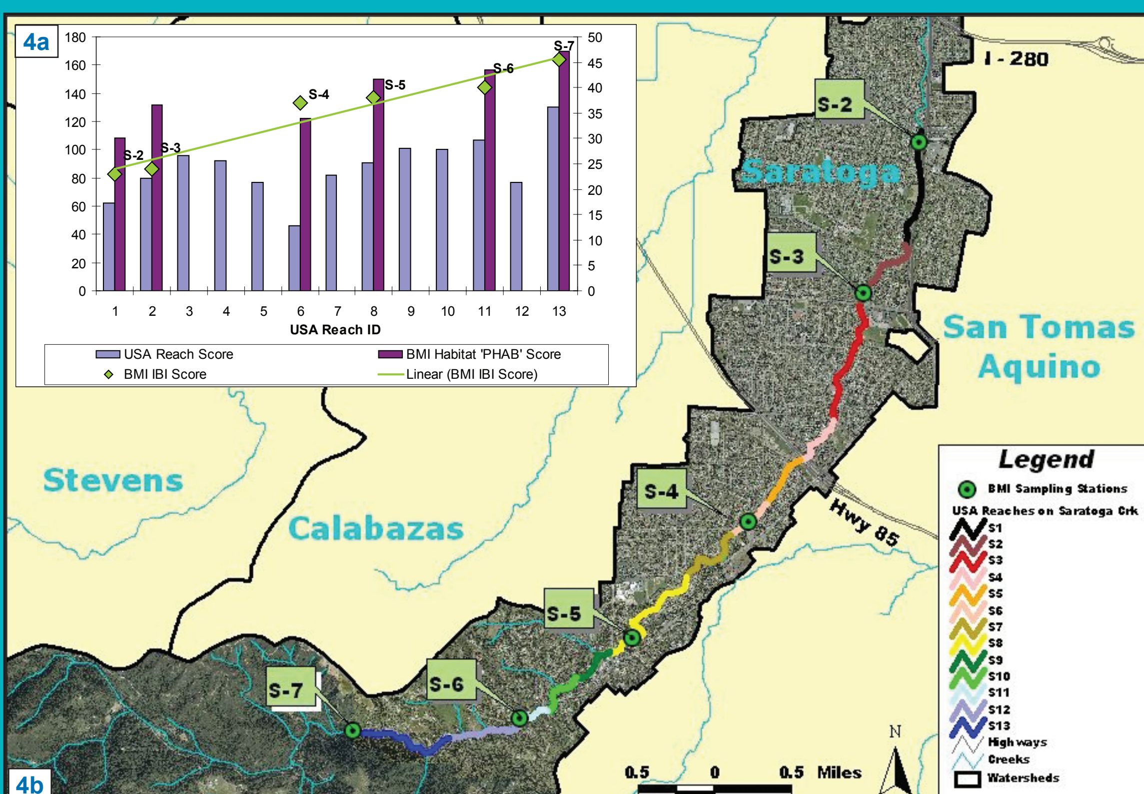

Figure 4. Saratoga Creek, Santa Clara County: a) USA reach delineations and bioassessment sampling locations; b) results of USA survey and bioassessment sampling (presented as scores for an index of biological integrity (IBI)).

Identifying Potential Water Quality Impacts and Stormwater BMPs

The suite of USA impact assessments is designed to identify areas where site-specific impacts occur[4] that appear to impact creek condition and in some cases could potentially be remediated by agencies and/or landowners. Examples of impacts commonly observed in urban watersheds are described and illustrated below.

Identifying Sites with Potential Water Quality Impacts

Trash

One component of the USA is to document creek areas impacted by trash. Trash sites are characterized by the type and severity of trash present, and by source (e.g., littering, illegal dumping and accumulation from upstream sources and adjacent land uses). These sites can be mapped and prioritized for follow-up assessments or management actions.

The Rapid Trash Assessment (RTA) protocol, originally developed by the San Francisco Bay Regional Water Quality Control Board, and later revised by the SCVURPPP, is another assessment tool designed to evaluate trash in wadeable, urban creeks. The RTA can be used to:

- Measure baseline levels of trash;
- Identify and prioritize trash problem areas;
- Identify potential sources of trash; and,
- Identify BMPs that target trash and evaluate their effectiveness.

The SMCWPPP implemented both the USA and URTA to evaluate the condition of trash in thirteen San Mateo County watersheds. Forty-two trash-impacted sites were identified using the USA, and 19 of those sites were further evaluated using the URTA (Figure 5).

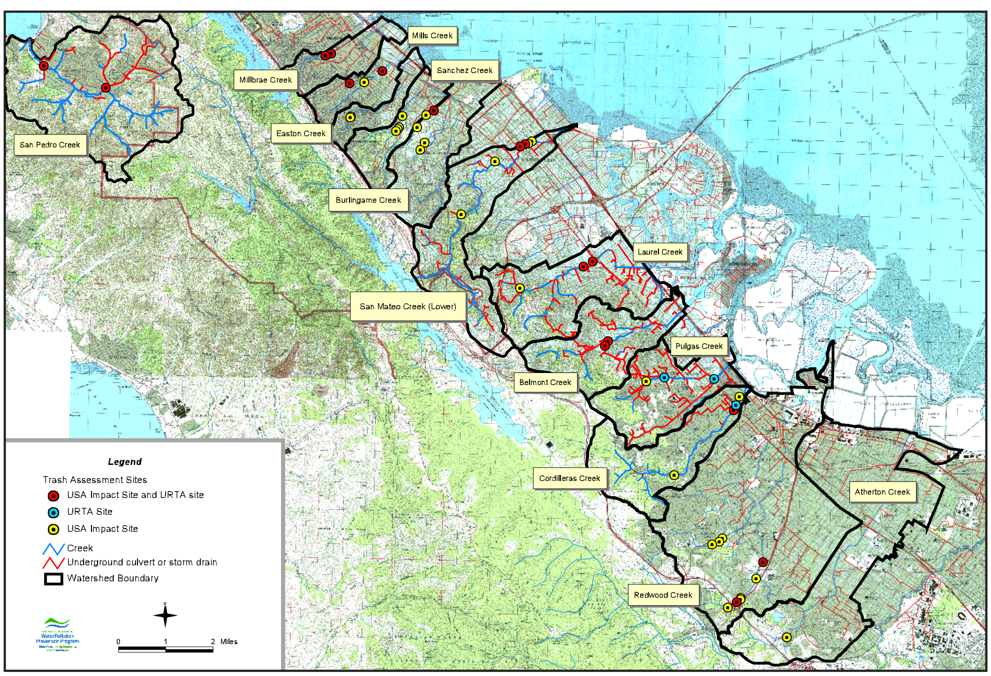

Figure 5. Impacted trash sites identified during USA and RTA surveys conducted in San Mateo County watersheds in 2006 and 2007.

[4] Historic impacts may also be detected and may provide insight into trends observed in past monitoring data, for example, evidence of a leaking sewer pipe that has been fixed might explain observed trends in biological indicators.

Illegal Connections and Illicit Discharges

Using the outfall and utility assessment forms, field crews collect basic information on the location, condition, and discharge characteristics of outfalls. The presence of sudsy water, oily sheens, and strong "rotten egg" odors in outfall discharge or from pipes that cross the riparian corridor and are leaking, may indicate illegal connections and/or leaks from sewer lines or other sources of nutrient enrichment such as fertilizers or animal waste (Figure 6a).

Additionally, the presence of a high volume of flow, chlorinated odors, and backwash pipes in the riparian corridor may indicate illicit discharges from swimming pools (Figure 6b) or fountains[5]. The presence of stained residues on outfall outlets or discolored discharges[6] (Figure 6c) may also indicate illicit discharges or areas up-pipe where further investigation is warranted. Surveys may also identify sites where historic events, such as a burst water line (Figure 6d), caused massive erosion and introduced sediment to the creek. Such information may provide insight into historic trends in biological or physical monitoring data and can indicate potential sites for rehabilitation (see below). In addition to noting discharge characteristics, tabulating the location and density of non-municipal outfalls in creek reaches may help to prioritize where to investigate in the event that pollutants are detected in a creek.

Figure 6. Illegal connections and illicit discharges: a) horse paddock encroaching on riparian corridor; b) pool backwash pipe entering creek; c) outfall with stains and residues; d) incision caused by historic burst water pipe.

[5] For an example, refer to SCVURPPP 2008b.
[6] For example, green or brown growths may be associated with high nutrient levels.

Water Diversions

Sites where water is diverted are typically easy to document during a USA survey (Figure 7). However, their localized and cumulative impacts are more difficult to estimate. While water diverting is not regulated through NPDES permits, this activity can greatly impact flow volume and habitat conditions, and therefore, may be a useful impact to document and refer to the appropriate agency.

Figure 7. Water diversion pipe and pump.

Infrastructure Repairs

The impact assessment forms include data fields to document damage and/or threats to infrastructure in the creek corridor. Typical examples of infrastructure requiring such attention include outfalls that are threatened from downcutting and widening of streambanks (Figure 8a), those with eroded footings (Figure 8b), and outfalls that are corroding, cracking, breaking and/or not functioning appropriately (Figure 8c). Other in-channel structures such as bridges, revetments, and grade controls may also exhibit signs of failing due to undercutting, thereby threatening property (Figure 8d), and causing erosion (Figure 8e).

Figure 8. Infrastructure requiring repair: 8a) Hanging outfall; 8b) Outfall threatened by erosion; 8c) Erosion and aggradation burying an outfall; 8d) Failed saccrete threatens private property; 8e) Erosion threatens private property.

Rehabilitation and Restoration

The USA is also designed to identify opportunities for rehabilitation and restoration activities within the riparian corridor. Rehabilitation opportunities refer to those that are site-specific and local in their extent. For example, there may be an opportunity to stabilize an area adjacent to a failing or threatened pipe, a streambank revetment, or where a streambank has failed in the absence of associated infrastructure. In contrast, restoration opportunities refer to those for which larger scale efforts within an entire creek reach, or across several creek reaches, may restore the integrity of biological and physical resources therein. For example, where a reach has relatively high quality habitats on its extremities and a degraded midsection, a restoration objective could be to restore instream habitat and floodplain functionality to the degraded area, thereby improving habitat contiguity and overall reach condition. The same scenario could exist across several reaches, whereby the restoration goal might focus on restoring conditions in a single degraded reach that is flanked by two reaches in which instream and/or riparian habitats are in better, and stable condition.

While implementation of rehabilitation and restoration projects is not within the purview of stormwater program NPDES permits, by documenting and referring information about impacts within the corridor to responsible agencies, stormwater programs can benefit from improvements in habitat conditions that result from such projects. Restoration projects are most feasible in areas where at least part of the riparian corridor is in public ownership. However, many of the impacts observed during USA surveys are associated with efforts by individual private property owners to control bank instability on their properties. Education and outreach could help landowners understand the impacts of such actions on creeks and potentially lead to the use of better practices in the future. For example, the Urban Creeks Council (www.urbancreeks.org) has developed[7] a Stream Management Program for Landowners (SMPL) that provides advice about creek care to Contra Costa County property owners. Services include free site visits and consultations on creek restoration techniques and associated permitting, including addressing issues such as bank failure, erosion, and flooding. Data generated from USA surveys could also assist property owners to target and optimize creek management and restoration efforts initiated through this type of stream management program (Figure 9).

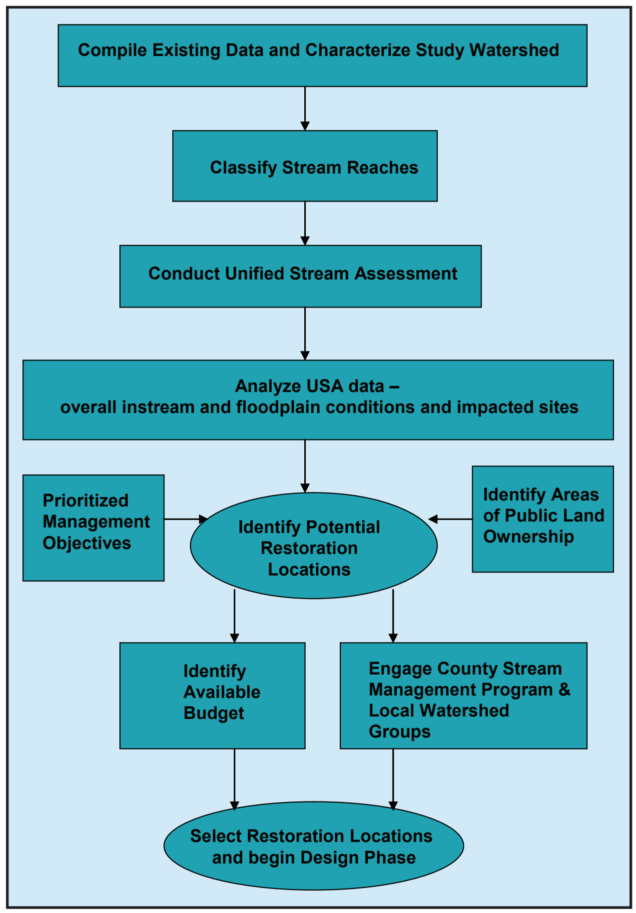

Figure 9. Steps involved in implementing a USA survey to identify potential restoration projects.

[7] This program was funded by the Contra Costa Clean Water Program.

Identifying Potential Rehabilitation Sites

Destabilized streambanks contribute sediment loads to creeks and degrade water quality and habitat. Streambank stabilization may be achieved by a range of methods, preferably involving bioengineering techniques to reestablish bank vegetation, and where necessary, altering the geomorphology of streambanks to re-establish a functional floodplain. Streambanks may destabilize for a number of reasons, many of which may be addressed by localized rehabilitation efforts (Figures 10 – 13).

Figure 10. Landslide debris entering creek below a vineyard, blocking a large part of a road culvert and introducing high volumes of sediment to the stream.

Figure 11. Recreational access contributing to elimination of streambank vegetation, and subsequent erosion and streambank instability.

Figure 12. Failing streambank revetment and subsequent erosion.

Figure 13. Bank scour resulting from hydromodification and channel engineering - the channel appears to have been straightened, and hardened on the opposite bank, thereby restricting flow and increasing its velocity, resulting in scour of the opposite bank.

Clearing of vegetation in the riparian corridor due for example to placement of utilities and roads (Figure 14) presents opportunities for revegetation to increase stream shading and streambank stabilization. In some cases, riparian plantings may be inappropriate because they do not provide enough root strength to stabilize streambanks (Figure 15) and include non-native ornamental plants that threaten the biological integrity of the riparian community (Figure 16).

Figure 14. Streambank revegetation opportunity.

Figure 15. Streambank erosion caused by inappropriate landscape pipe placement and plantings.

Figure 16. Decorative ornamental streambank plantings.

Hobby farms, where domesticated animals are allowed access to the creek (Figure 17), or are maintained in enclosures that encroach upon the riparian corridor and have potential to influence water quality through runoff in addition to the physical encroachment are more common in the less densely urbanized areas of watersheds than in the densely developed areas. Such impacts may be addressed by advocating exclusionary fencing and development of alternative water sources, or modifying the location and drainage of enclosure facilities to ensure that runoff does not drain directly into the creek. Barriers to fish passage are commonly created by road culverts (Figure 18), grade control structures, and dams (Table 4). Decisions about whether and how to remove or remediate such barriers largely depends on the species of concern[8]. In some cases, complete removal may be the best option, however, remediation options may include creation of low flow channels or notches, or modification of existing grade control by creating either a series of jump pools along it, or one below an existing grade control structure and a landing pool above it.

Figure 17. Goats with access to riparian corridor.

Figure 18. Highway culvert potentially acting as a barrier to fish passage.

[8] A barrier for a smaller warmwater species is usually not a barrier to larger coldwater species.

Table 4. Stream crossing impacts observed in Calabazas Creek, Santa Clara County, 2005.

SurveyReach ID	Stream Crossing Description	Performs Grade Control	Fish Blockage								Restoration Candidate	Restoration Description
			Severity	Total	Partial	Drop Too High	Drop (in)	Flow Too Shallow	Depth (in)	Other		
1	Miller Ave	Y	4	N	N	N		Y	1	Velocity and slanted drop at u/s end.	3	Construct Low flow channel. Location at top of lengthy, continuous concrete channel makes it low priority compared to sites in reaches with greater habitat potential up- and downstream.
4	Bollinger Bridge	Y	5	Y	N	Y	54	Y	3		1	Bridge Retrofit - Planned to begin Summer, 2005.
5	Old Bollinger Bridge	N	0	N	N	N		N	NA		1	Remove crossing; appears non-functional and constricts channel, causing erosion.
7	Blaney Ave	Y	5	Y	N	Y	48	Y	1		1	Notch; reduce drop
8	Rainbow Drive	Y	4	Y	N	Y	48	Y	2	Velocity	1	Notch; reduce drop
9	Pedestrian Bridge	N	0	N	N	N		N	NA		1	Restructure Bridge
10	Hwy 85	Y	3	N	Y	N		N	4	Low flows	3	Construct low-flow channel.
12	Saratoga-Sunnyvale Box Culvert	Y	3	N	Y	N		Y	2		2	Construct low-flow channel in culvert.
13	SPRR	Y	3	N	Y	N		Y	2		3	Notch on grade control structure.
14	Wardell Road	Y	2	N	Y	N		N	30		3	Notch on grade control structure
15	Comer Drive	N	0	N	N	N		N	NA		3	Aggrading sediment could threaten road in high flows.
Restoration Candidate: 1 is highest priority 3 is lowest priority												
Severity: 5 is most severe, 1 is least severe												

Identifying Potential Restoration Sites

Restoration projects may involve changing the creek planform to increase sinuosity and to ameliorate impacts caused by channelization. Other restoration examples include setting back and revegetating streambanks to reconnect floodplains to active channels, improving existing instream and riparian habitat, daylighting streams, and creating stormwater storage retrofits. Assessments of instream and floodplain condition as well as impacts recorded during a USA survey can be used to identify reaches where restoration potential exists. For example, scores may be used to identify reaches (or parts of reaches) of higher functional integrity that are isolated from each other and would benefit[9] from being connected and enlarged when the intervening area is enhanced by restoration techniques. A Watershed Stewardship Plan developed for Calabazas Creek, Santa Clara County (SCVWD 2005), provides a local example of this approach. In this case, key criteria used to identify potential restoration areas

[9] Often areas of higher quality habitat support greater ecological integrity, and may act as refugia for populations. If such areas are connected, and interveneing area is enhanced, the quantity and quality of accessible habitat can be increased and can support a larger and healthier biological community.

included: 1) good public access and ownership of creek right-of-way; 2) adequate space to set back streambanks and restore floodplain functionality; 3) existing documentation and/or observations of aquatic communities; 4) potential to reconnect high quality habitats up- or downstream. The Plan identified the geomorphic reach with the greatest restoration potential (Figure 19) as the one that was moderately unstable, and where erosion was likely to continue due to the presence of uncoordinated streambank-stabilization efforts that had hardened the reach and were contributing to existing erosion processes. The Plan called for implementation of biotechnical streambank stabilization within part of this geomorphic reach (in USA Reach 8) because: A) Reach 8 did not exhibit high USA scores for in-stream habitat nor for riparian condition; B) it traversed along a publicly owned park; and C) it was located between two other USA reaches that exhibited high quality habitat features that could be enhanced by improvements to the reach between them.

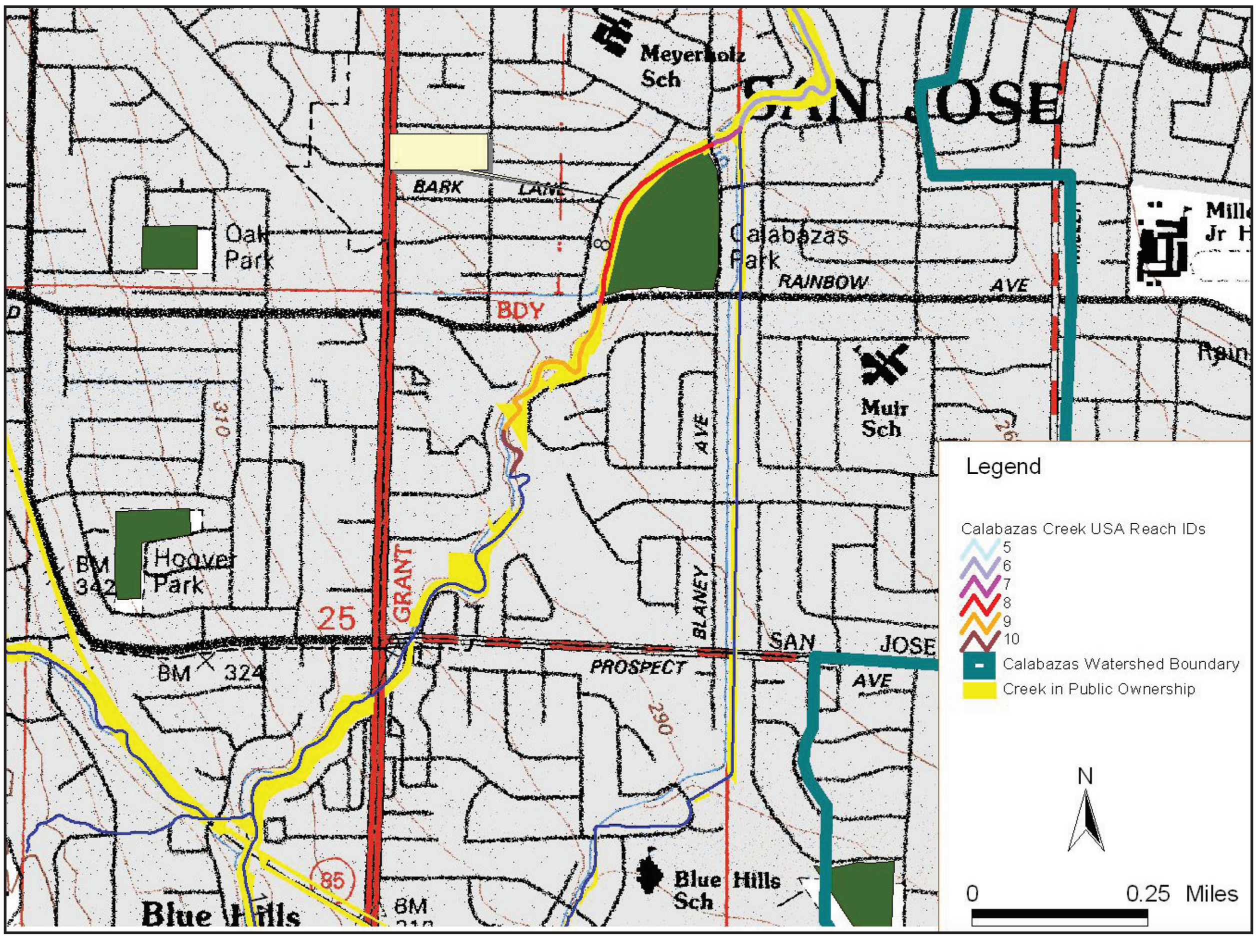

Figure 19. Potential restoration reach, Calabazas Creek, Santa Clara County.

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Summary

The USA protocol is a relatively rapid and inexpensive tool that has been used successfully in the San Francisco Bay area to meet a wide range of monitoring program objectives, including guiding the development of monitoring plans; assisting in the interpretation of existing physical, chemical, and biological monitoring data; identifying potential water quality impacts and relevant BMPs; and identifying potential rehabilitation and restoration sites. In future years, Phase I municipal stormwater programs in the Bay Area will likely be required to conduct stream surveys using the USA or an equivalent method. Once a program's monitoring objectives have been established, the USA protocol can be tailored to efficiently meet the type and level of data collection required to achieve those objectives. The flexibility inherent in this assessment tool, together with its relatively low cost for the diversity and depth of information it can provide, makes it a valuable component of stormwater program toolkits.

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